UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest and Alaska Fisheries Center
Resource Assessment and Conservation
Engineering Division
7600 Sand Point Way Northeast
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Seattle, Washington 98115-0070

March 31, 1989

CRUISE RESULTS
NOAA SHIP MILLER FREEMAN
Cruise No. 88-01

Echo Integrator-Midwater Trawl Survey of
Spawning Pollock in the Aleutian Basin

CRUISE PERIOD, AREA, AND SCHEDULE

After initial tests and calibration of the acoustic system in Puget Sound (January 6-13 and 20-22), the NOAA Ship Miller Freeman departed January 21, 1988, en route to Kodiak. Operations commenced January 28, 1988, in Kodiak and a survey of spawning pollock in the Aleutian Basin was completed March 4, 1988. The vessel's itinerary was as follows:

January 6	Leg I. Departure from Pacific Marine Center (PMC); conduct calibration measurements in Puget Sound.
January 6-11	Conduct calibration tests and target strength measurements in Port Susan and the Strait of Georgia.
January 12-13	Calibration of acoustic system at Pier 36.
January 14-20	In port, PMC.
January 20-22	Begin Leg II. Conduct calibration tests and test net system in Puget Sound.
January 22-27	Transit to Kodiak; embark scientists.
January 28-February 2	Transit to International Zone.

February 2-11	Survey operations near International Zone in Aleutian Basin.
February 12-13	In port, Adak.
February 14-March 4	Begin Leg III. Survey operations near Bogoslof Island in Aleutian Basin.
March 4	Arrive Dutch Harbor.

The principal objectives of the survey were to:

1. Collect echo integrator and midwater trawl data necessary to determine the distribution, biomass, and biological composition of spawning pollock in selected portions of the Aleutian Basin, including the area outside the U.S. Fishery Conservation Zone (the International Zone, also known as the "Donut Hole") and the area near Bogoslof Island, where extensive fishing operations for spawning pollock have occurred in recent years.

2. Collect Pacific whiting and walleye pollock target strength data for use in scaling echo integration values to fish density.

3. Collect measurements of a standard sphere to provide real-time calibration information about the acoustic system and to detect changes in system performance with changes in transducer depth.

4. Collect samples of pollock for reproductive and stock structure studies.

VESSEL, ACOUSTIC EQUIPMENT, AND TRAWL GEAR

The survey was completed on board the NOAA ship Miller Freeman, a 66 m stern trawler, equipped for fisheries and oceanographic research. The acoustic system used during this cruise was an echo integration and target strength measurement system operating at 38 kHz. The transducer, housed in a dead-weight fin, was towed approximately 20 m below the surface at a speed of 9 to 11 knots. System electronics were housed in a van mounted to the weather deck of the vessel.

During Leg I, echo sign was sampled using a Diamond 1000 mid-water trawl. The Diamond trawl was fished with 1.5 x 2.1 m steel V-doors, 55 m dandylines (two per side), and a 113 kg tom weight attached to each lower wing tip. Mesh sizes (stretched

measure) ranged from 81.3 cm (32 inches) in the wings and forward part of the body to 8.9 cm (3.5 inches) in the cod end, with a 3.175 cm (1.25 inch) mesh cod end liner. The average vertical mouth opening of the trawl was approximately 15 to 18 m. During Legs II and III, echo sign was sampled using a Northern Gold 1200 midwater rope trawl (NET[1] Systems, Inc.). The rope trawl, which had ropes in the forward section and mesh sizes (stretched measure) ranging from 162.6 cm (64 inch) forward to 8.9 cm (3.5 inch) in the cod end, was outfitted with 82 m bridles, 5 m^2 doors, 273 or 545 kg tom weights, and a 3.175 cm (1.25 inch) mesh cod end liner.

SURVEY METHODS

Initial system tests and target strength measurements were conducted in Puget Sound and the Strait of Georgia during January 6-11. Calibration of the acoustic system using the University of Washington's calibration barge was carried out on January 13 and 14 at Pier 36 in Seattle. In addition, five standard sphere calibrations were conducted to determine changes in system performance with transducer depth on the dates shown in Table 1. Calibration consisted of suspending either a copper or tungsten carbide sphere with known acoustic properties below the fin and lowering the fin through the water column.

The southern portion of the International Zone (south of approximately 57 degrees north latitude) was surveyed February 2-11 (Fig. 1). The first portion was surveyed using parallel transects spaced at approximately 40 nmi intervals during the period February 2-6, 1988. Upon completion of this survey pattern, a series of zigzag transects was completed over the northern and western section of Bowers Ridge. The next two days were devoted to resurveying a portion of the international zone where foreign vessels had been reported.

The region near Bogoslof Island was surveyed between February 12 and March 3, 1988. The area from Unimak Pass to longitude 170° W. was surveyed using parallel transects (Fig. 2). The first portion of the area was surveyed with tracklines spaced at 20 nmi intervals. Once a significant amount of echo sign determined to be spawning pollock was observed, the spacing was reduced to 10 nmi.

During Legs II and III of the cruise, significant echo sign was sampled with the midwater rope trawl described above. At most trawl stations, CTD (conductivity/temperature/depth) and XBT

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[1] Reference to trade name does not imply endorsement by the National Marine Fisheries Service, NOAA.

(expendable bathythermograph) casts were made. Biological samples were collected from trawl hauls to determine sex, size, age, and maturity composition of pollock. Other samples were collected for genetic and morphometric/meristic studies to examine the stock structure of pollock in the basin.

RESULTS

Table 2 summarizes the number of fish sampled for different biological characteristics, as well as the CTD casts associated with each haul. An additional five CTD casts were made at locations where trawl hauls were not taken. Summaries of haul positions and catch data are shown in Table 3, and species distributions among haul catches are presented in Table 4.

Leg I

Preliminary analysis of the standard sphere calibration data indicated a 9 decibel difference in target strength between the copper and tungsten carbide spheres, which agreed with published results. Overall system performance appeared to change with the depth of suspension of the transducer. The magnitude of this change in system performance is currently being analyzed. Six trawl hauls (Table 2) taken on Leg I provided fish samples for target strength measurements. Hauls 1, 2, and 4 yielded mainly Pacific whiting; hauls 5 and 6 were composed predominantly of walleye pollock; and haul 3 had very few fish (Table 2).

Leg II

During the entire survey of the International Zone (1,655 nmi of transects), no significant echo sign of any kind was observed. The only evidence of pollock was the occurrence of widely spaced "single targets" in the acoustic beam of the echo sounder, indicating extremely low densities of pollock; thus, only three hauls were taken (hauls 9, 10 and 11, Table 3). Catch rates from these trawl hauls made during Leg II ranged from 13 to 61 fish per hour. Using rough measurements of the mouth opening of the net (about 30 m vertical by 45 m horizontal) and distance fished, these catch rates indicate densities ranging from about 2 to 8 fish per million cubic meters. Size composition (Fig. 3a) and age composition (Fig. 3b) of pollock in the International Zone indicate that the majority of fish sampled were older, larger fish, with the 1978 year class being the most abundant. Except for a single male walleye pollock, all pollock observed during Leg II were determined to be mature but not spawning. Densities observed during the survey over Bowers Ridge were of the same magnitude as those observed in the International Zone, but no samples were collected due to the paucity of echo sign.

Special efforts were expended to sample in areas where foreign fishing vessels were observed. Prior to about February 5, foreign vessel positions were reported primarily in the extreme southern portion of the International Zone west of 180° longitude. At about this time, there was a shift of reported foreign fishing effort to the area east of 180°. Samples taken near the foreign vessels did not provide any evidence of fishable aggregations of pollock. Several foreign vessels were approached, but none was observed with its net in the water. Foreign vessels observed on radar also did not appear to be fishing; most appeared to be stationary.

Leg III

A total of 1,169 nmi of transects was completed during Leg III. A large concentration of spawning pollock was observed within an approximate radius of 40 nmi of Bogoslof Island (Fig. 2). Pollock densities as high as about 20 kg per m^2 were observed. The fish appeared to be highly aggregated, with high density areas approximately 5 x 5 nmi in size separated by areas of low densities. Boundaries of the Bogoslof spawning area were delineated based on the size and maturity composition of the catches (Fig. 2). The size composition of pollock collected within the spawning aggregation was relatively constant; most fish were between 43 and 52 cm long (Fig. 4a). Within the spawning aggregation, 36.1% of the fish were from the 1978 year class, 10.7% were from the 1979 year class, and 10.1% were 1982 year class fish (Fig. 4b). Comparing the Bogoslof pollock to those collected inside the International Zone (Figs. 3a, 3b, 4a, and 4b) indicates that pollock in both regions have relatively similar length and age compositions, although some younger year classes caught in the Bogoslof samples did not appear among International Zone fish.

Maturity stages of pollock within the Bogoslof aggregation were examined to determine time of spawning (Fig. 5). During the Bogoslof region survey, prior to about February 26, most females were mature but not spawning. After this time, most females were spawning and some were observed to be post-spawning, particularly during March 2-3. During the entire period from February 22-March 3, almost all males were classified as spawning. The progression of maturity of female pollock during this period indicates that spawning occurred near the beginning of March. Three bongo net plankton samples taken near the spawning pollock concentrations between February 29 and March 3 contained large numbers of pollock eggs, supporting the observations of spawning time made above.

The pollock were segregated by sex throughout the survey period. Sex composition in trawl hauls during Leg III ranged from 12 to 92% males (Fig. 6). Occasionally, trawl hauls made very close to one another would result in one haul catching mostly females and the next catching mostly males. High densities of spawning pollock made obtaining a representative sample of fish difficult within these aggregations. To avoid capturing very large numbers of pollock, it was often necessary to sample only the top or the edge of an aggregation. At several locations, multiple trawl hauls were made within one aggregation to attempt to determine its biological composition. Unfortunately, sampling fish from the deepest layer of the large, dense schools was impossible; thus, we could not obtain the representative samples necessary for determining sex composition within the schools. With the limited number of trawl hauls completed, no apparent relationship between sex composition within the haul and time of day or depth of trawl was observed.

SCIENTIFIC PARTY

Leg I: January 6-11

Jim Traynor	Chief Scientist	NWAFC*
William Karp	Fishery Biologist	NWAFC
Daniel Twohig	Electronics Technician	NWAFC
Neal Williamson	Statistician	NWAFC
John Garrison	Electronics Technician	NWAFC
Doug Smith	Fishery Biologist	NWAFC
Pat Sullivan	Statistician	NWAFC
Ken Cirillo	NOAA Corps Officer	NWAFC
Sarah Hinckley	Fishery Biologist	NWAFC
Phillip Wyman	Fishery Biologist	NWAFC
Suam Kim	Fishery Biologist	NWAFC
Bill Shaw	Fishery Biologist	Pacific Biological Station, Canada
Mark Saunders	Fishery Biologist	Pacific Biological Station, Canada

* NWAFC - Northwest and Alaska Fisheries Center, Seattle, Washington

Leg II: January 21-February 11

Jim Traynor	Chief Scientist	NWAFC
Daniel Twohig	Electronics Technician	NWAFC
John Garrison	Electronics Technician	NWAFC
Doug Smith	Fishery Biologist	NWAFC
Ken Cirillo	NOAA Corps Officer	NWAFC
Jennifer Sassano	Fishery Biologist	NWAFC
Peter Munro	Operations Res. Anal.	NWAFC
Kazuyuki Teshima	Fishery Biologist	Far Seas Fisheries Research Laboratory, Japan

Leg III: February 12-March 4

Jim Traynor	Chief Scientist	NWAFC
William Karp	Fishery Biologist	NWAFC
Daniel Twohig	Electronics Technician	NWAFC
John Garrison	Electronics Technician	NWAFC
Doug Smith	Fishery Biologist	NWAFC
Ken Cirillo	NOAA Corps Officer	NWAFC
Jennifer Sassano	Fishery Biologist	NWAFC
Peter Munro	Operations Res. Anal.	NWAFC
Rudy Kloser	Electronics Engineer	CSIRO Marine Laboratory, Australia

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Table 1. Standard sphere calibration summary for Miller Freeman Cruise 88-1.

Date	Location	Transducer Depths (range) (m)
1/7/88	Port Susan, Puget Sound	10-50
1/10/88	Port Susan, Puget Sound	2-45
1/31/88	Makushin Bay, Unalaska I.	2-75
2/16/88	Makushin Bay, Unalaska I.	2-72
3/3/88	Makushin Bay, Unalaska I.	2-80

Table 2. Biological samples collected during Miller Freeman Cruise 88-1. Numbers indicate number of fish sampled for each data type. CTD deployed where indicated.

Haul#	Length Maturity	Otoliths	Weights	Electro-phoresis[1]	M-DNA[1]	Morphometrics Meristics[1]	Fecundity[1]	CTD
Leg I--Puget Sound								
1	114[2]							
2	275		129					
3								
4								
5	189[2]							
6	296		123					
Leg II--International Zone								
7	289	100		50				
8	330							
9	41	41		55	30			X
10	16	16		24	10			
11	72	43		49	10	29		
Leg III--Aleutian Basin								
12	192	50		100	25	100		
13	157			50	25	50		
14	54							X
15	315							
16	307							

[1] Collections made for stock identification studies.

[2] Lengths only were taken.

Table 2. (cont.) Biological samples collected during Miller Freeman Cruise 88-1. Numbers indicate number of fish sampled for each data type. CTD deployed where indicated.

Haul#	Length Maturity	Otoliths	Weights	Electro-phoresis[3]	M-DNA[1]	Morphometrics Meristics[1]	Fecundity[1]	CTD
17	282	100					26	
18	228	100	103				5	X
19	223	78	100				2	X
20	347	100	100					X
21	239	85	100					
22	388	100						
23	229	100	100					X
24	356	100					1	X
25	330	96						X
26	239		100					X
27	300							X
28	258							
29	249							
30	311						1	
31	331	100						
32	346							X
33	298							
34	274	100						
35	273	100	100				1	
36	235							(2)X

[3] Collections made for stock identification studies.

Table 3. Summary of pertinent midwater trawl position, depth and catch data for Cruise MF 88-1. (Start positions are north latitude and west longitude, unless otherwise indicated.)

Haul #	Date	Equil. Hour	Start Position Lat.	Start Position Long.	Depth (fm) Gear	Depth (fm) Bot.	Catch (lbs) Pollock	Catch (lbs) Whiting	Catch (lbs) Other
1	1/07	22	48 03	122 23	49	98	5	110	77
2	1/08	01	48 04	122 20	52	67	4	614	22
3	1/08	10	48 04	122 20	48	70	4	1	5
4	1/08	18	47 54	122 21	75	111	5	251	76
5	1/09	21	49 46	124 10	69	326	399	18	127
6	1/10	01	49 28	124 02	58	110	827	10	133
7	1/31	18	53 52	167 40	250	850	3354		4
8	2/01	11	54 48	171 43	250	1850	571		11
9	2/08	15	56 05	179 16E	123	2050	71		57
10	2/09	11	55 52	179 08	118	2060	27		23
11	2/09	22	55 36	178 29	177	2050	122		15
12	2/13	24	52 27	174 08	200	550	975		12
13	2/14	20	53 48	168 47	249	1157	340		8
14	2/14	22	53 48	168 47	125	1157	74		21
15	2/17	24	54 18	165 58	125	156	903		78
16	2/19	18	54 44	166 34	110	154	4129		
17	2/22	16	54 21	167 04	237	400	947		9
18	2/22	18	54 21	167 02	147	379	4209		3
19	2/23	24	54 01	167 13	171	698	1260		4
20	2/25	14	53 49	168 13	250	785	4868		2
21	2/26	02	54 30	168 29	181	725	443		3
22	2/26	17	53 27	168 47	164	650	1500		
23	2/27	21	53 09	169 22	115	667	2418		2
24	2/28	24	53 41	169 38	211	1372	2520		2
25	2/29	11	54 21	168 47	134	1000	5600		
26	2/29	13	54 16	168 47	152	1000	551		1
27	2/29	15	54 17	168 55	200	1000	528		6
28	3/01	04	54 12	168 59	164	1000	636		13
29	3/01	06	54 22	168 52	104	1190	14900		
30	3/01	14	53 37	168 42	125	828	8000		

Table 3. (cont) Summary of pertinent midwater trawl position, depth and catch data for Cruise MF 88-1.

Haul #	Date	Equil. Hour	Start Position Lat.	Long.	Depth (fm) Gear	Bot.	Catch (lbs) Pollock	Whiting	Other
31	3/01	16	53 37	168 43	160	805	7800		
32	3/01	24	53 37	168 40	139	866	1110		3
33	3/02	03	53 37	168 39	200	700	4080		
34	3/02	09	53 56	167 35	175	823	14000		
35	3/02	21	53 54	167 38	185	925	666		6
36	3/02	23	53 56	167 34	191	925	425		15
B1	2/29	19	54 22	168 58	Oblique tow from 0 to 500 meters. Large quantity of pollock eggs caught. Cable angle 50 degrees.				
B2	3/02	04	53 38	168 40	Oblique tow from 0 to 500 meters. Large quantity of pollock eggs caught. Cable angle 45 degrees.				
B3	3/03	03	53 53	167 39	Oblique tow from 0 to 500 meters. Large quantity of pollock eggs caught. Cable angle 45 degrees.				

Table 4. Frequency of occurrence, in numbers of tows, and catch information for various species during the Miller Freeman Cruise 88-1.

Species or species group	Frequency		Total Catch	
	Number of tows	Percent of tows	Pounds	Percent
PUGET SOUND AND STRAIT OF GEORGIA (LEG I)				
Walleye pollock	6	100.0	1307.6	47.50
Pacific whiting	6	100.0	1004.0	36.50
Spiny Dogfish	5	83.3	424.5	15.40
English Sole	2	33.3	.8	.03
Squid (Unident)	1	16.7	5.0	.18
Jellyfish	1	16.7	5.0	.18
Redstripe Rockfish	1	16.7	1.5	.06
Pacific Sanddab	1	16.7	.5	.02
Flathead Sole	1	16.7	.5	.02
Pacific Herring	1	16.7	.3	.01
Lamprey (Unident)	1	16.7	.1	<.01
		Total	2749.8	
BERING SEA (LEGS II & III)				
Walleye Pollock	30	100.0	100525.7	99.76
Jellyfish (Unident)	14	46.7	61.3	.06
Smooth Lumpsucker	12	40.0	123.5	.12
Squid (Unident)	12	40.0	18.4	.02
Myctophid (Unident)	8	26.7	6.9	.01
King Salmon	3	10.0	12.0	.01
Lamprey (Unident)	3	10.0	4.5	<.01
Eulachon	2	6.7	1.8	<.01
Pacific Cod	1	3.3	60.0	.06
Flathead Sole	1	3.3	5.0	<.01
Loligo Squid	1	3.3	1.0	<.01
		Total	100820.1	

FIGURES

Fig. 1. Map of survey area, Miller Freeman Cruise 88-1, Leg II, showing acoustic survey tracklines. Special effort in vicinity of foreign vessels indicated by dashed line.

Fig. 2. Map of survey area, Miller Freeman Cruise 88-1, Leg III, showing acoustic survey tracklines. Approximate area of spawning aggregation is indicated by dashed line.

Fig. 3a. Walleye pollock size composition, Miller Freeman Cruise 88-1, in the International Zone of the Aleutian Basin (Leg II, n=129).

Fig. 3b. Walleye pollock age composition, Miller Freeman Cruise 88-1, in the International Zone of the Aleutian Basin (Leg II, n=94).

Fig. 4a. Walleye pollock size composition, Miller Freeman Cruise 88-1, near Bogoslof Island (Leg III, n=5807).

Fig. 4b. Walleye pollock age composition, Miller Freeman Cruise 88-1, near Bogoslof Island (Leg III, n=888).

Fig. 5. Percent of male and female walleye pollock at four different maturity stages over time, in spawning aggregations near Bogoslof Island, Miller Freeman Cruise 88-1, Leg III.

Fig. 6. Sex composition of walleye pollock observed in spawning aggregations near Bogoslof Island. Arrows indicate trawl hauls obtained from the same spawning aggregation (hauls 25-29, hauls 30-33, and hauls 34-36).

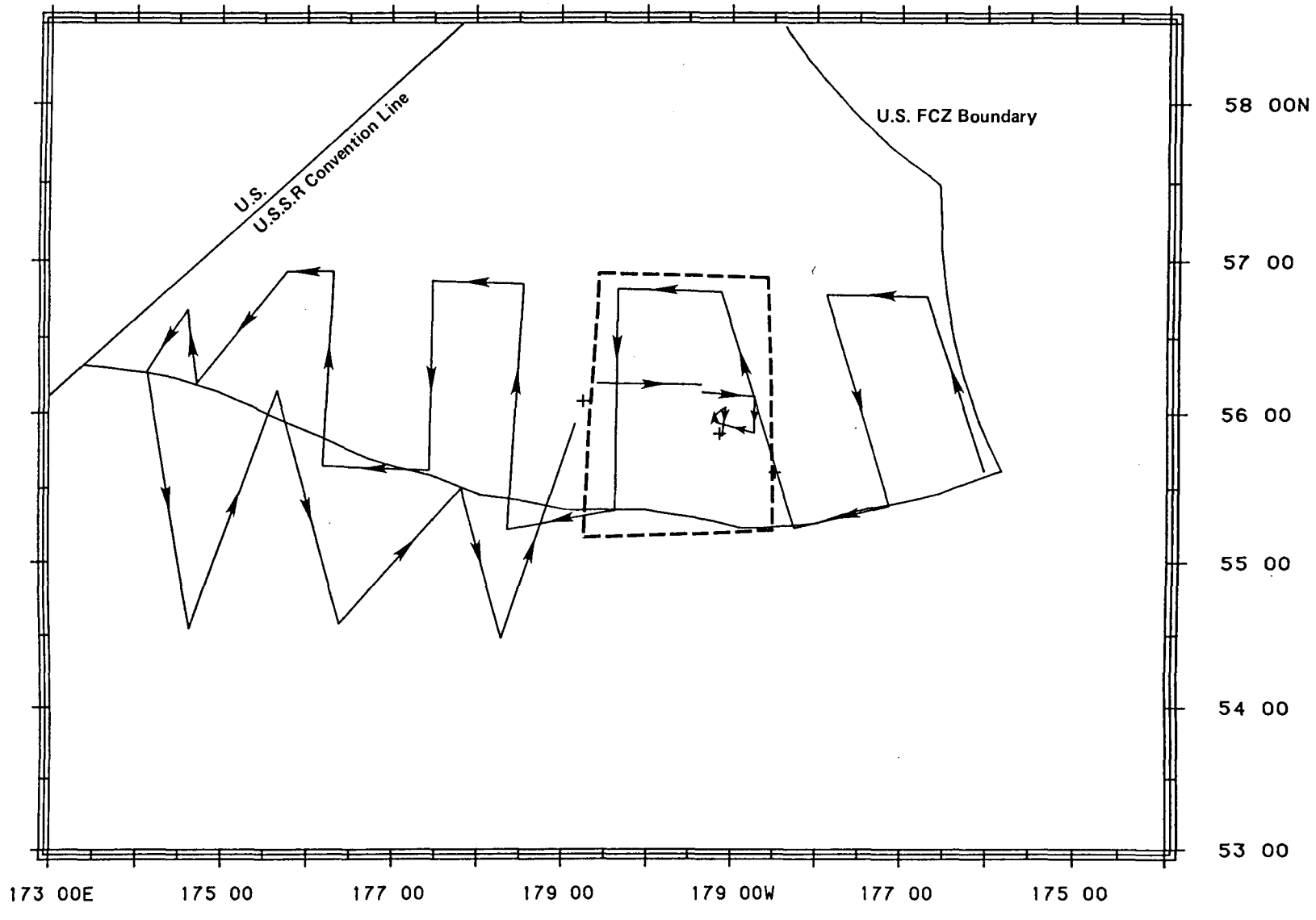

Fig. 1. Map of survey area, Miller Freeman Cruise 88-1, Leg II, showing acoustic survey tracklines. Special effort in vicinity of foreign vessels indicated by dashed line.

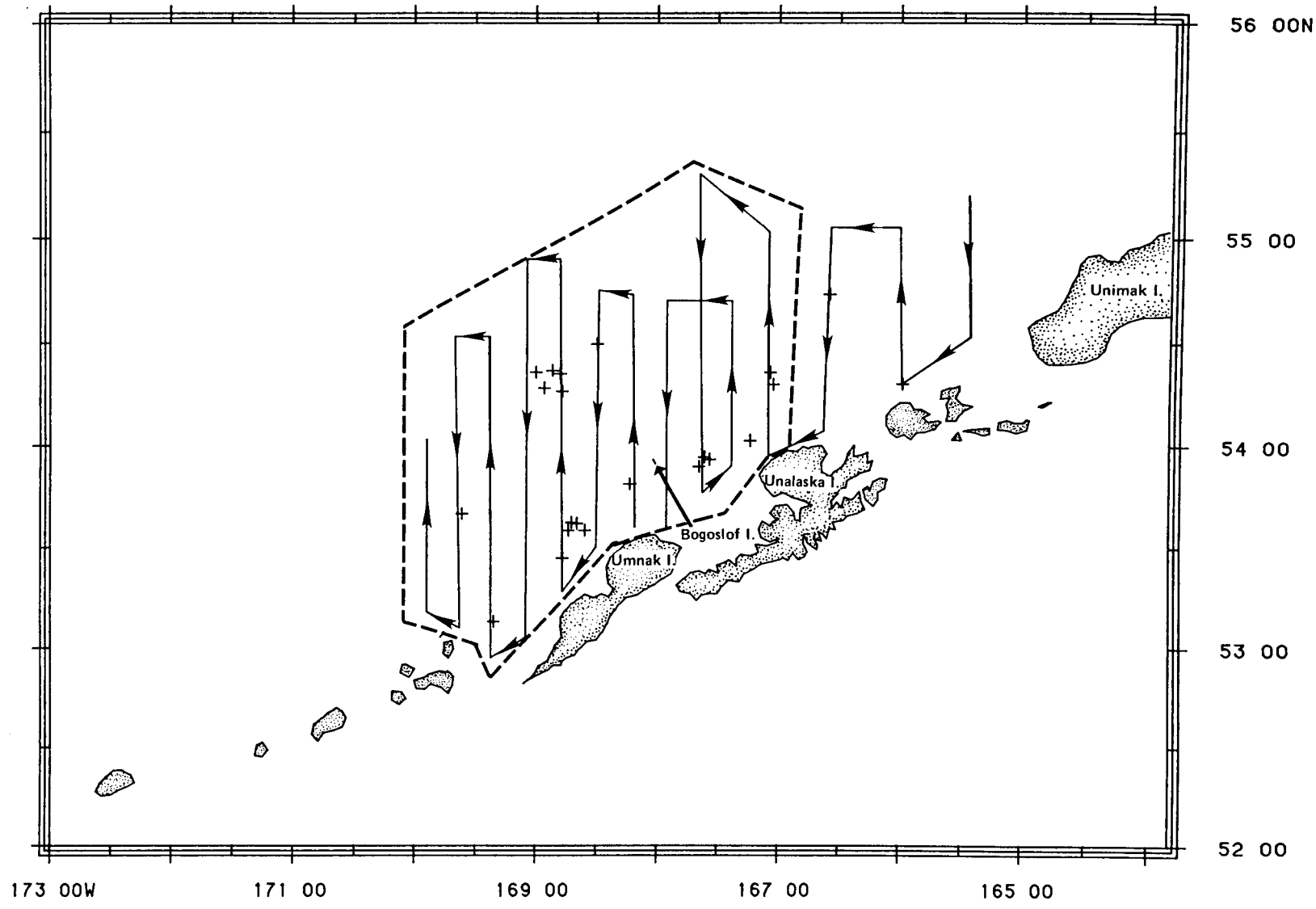

Fig. 2. Map of survey area, Miller Freeman Cruise 88-1, Leg III, showing acoustic survey tracklines. Approximate area of spawning aggregation is indicated by dashed line.

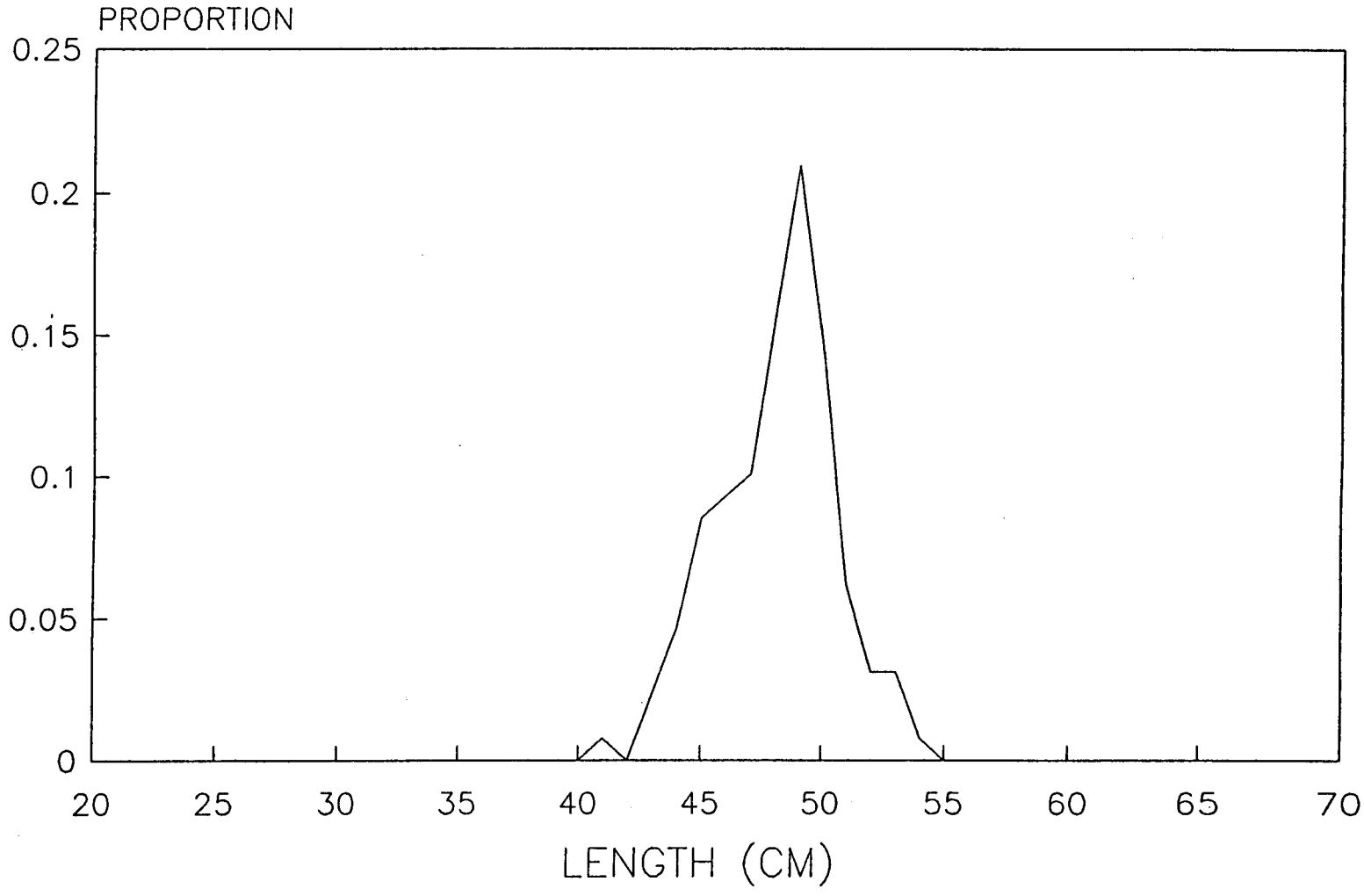

Fig. 3a. Walleye pollock size composition, Miller Freeman Cruise 88-1, in the International Zone of the Aleutian Basin (Leg II, n=129).

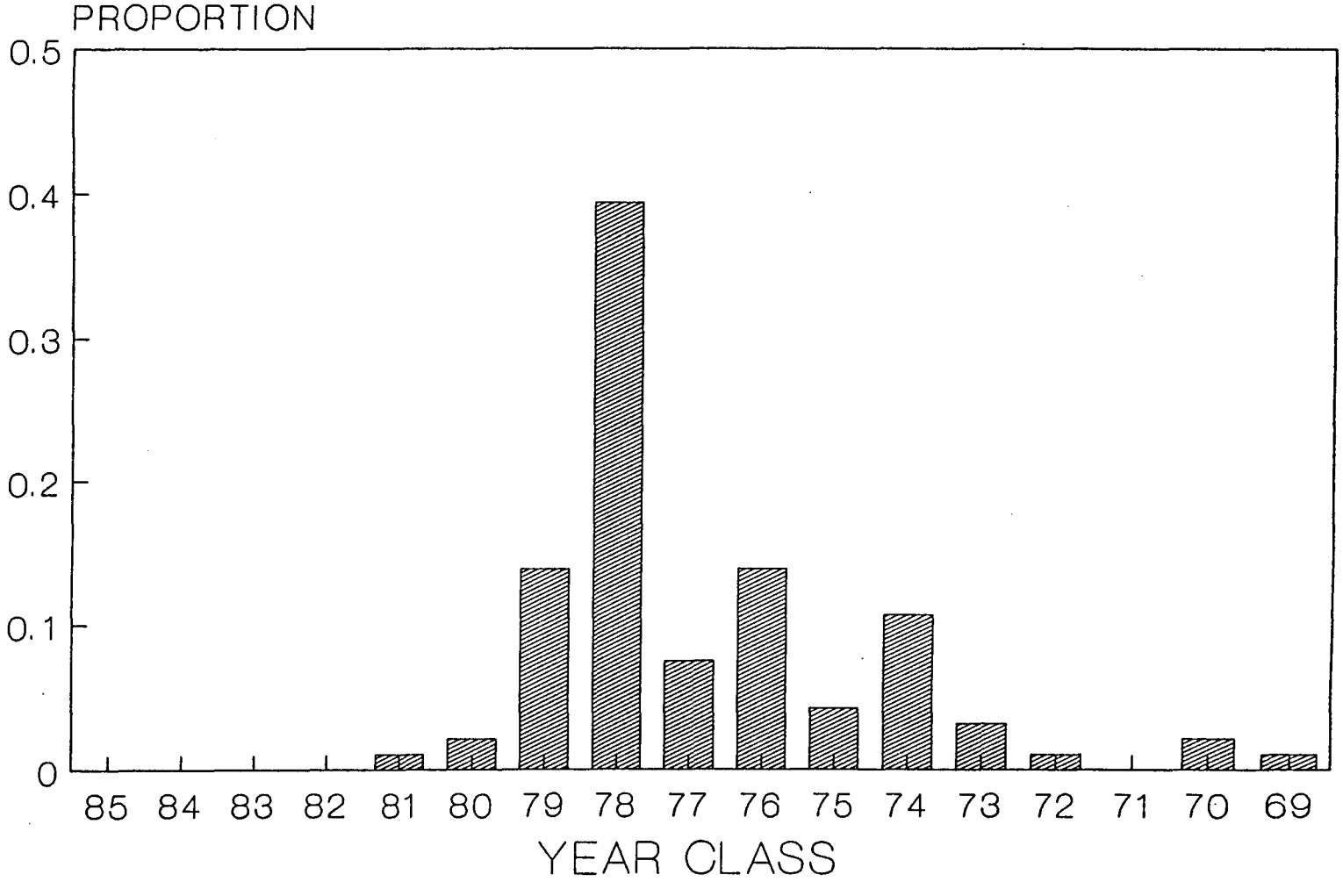

Fig. 3b. Walleye pollock age composition, Miller Freeman Cruise 88-1, in the International Zone of the Aleutian Basin (Leg II, n=94).

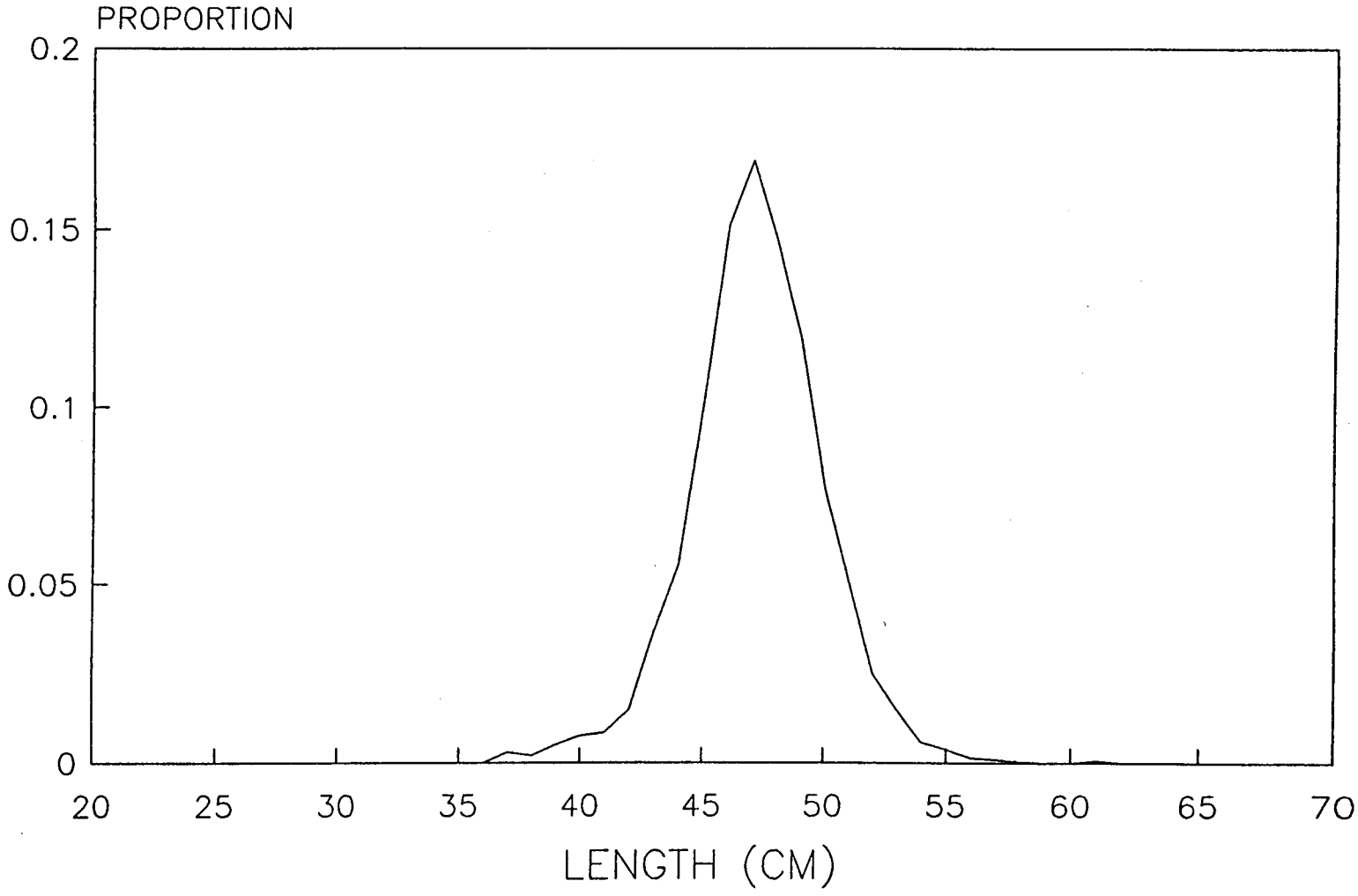

Fig. 4a. Walleye pollock size composition, Miller Freeman Cruise 88-1, near Bogoslof Island (Leg III, n=5807).

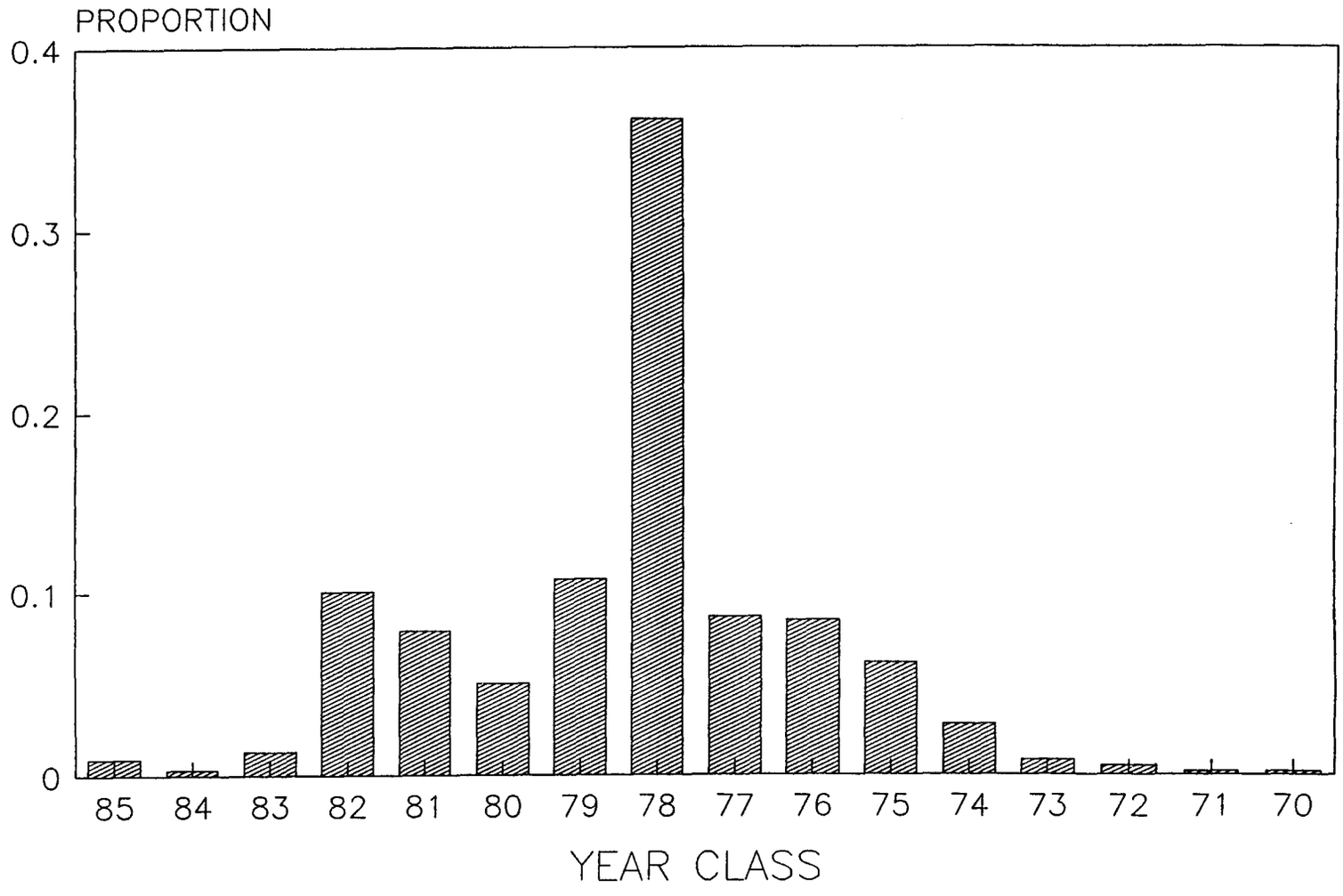

Fig. 4b. Walleye pollock age composition, Miller Freeman Cruise 88-1, near Bogoslof Island (Leg III, n=888).

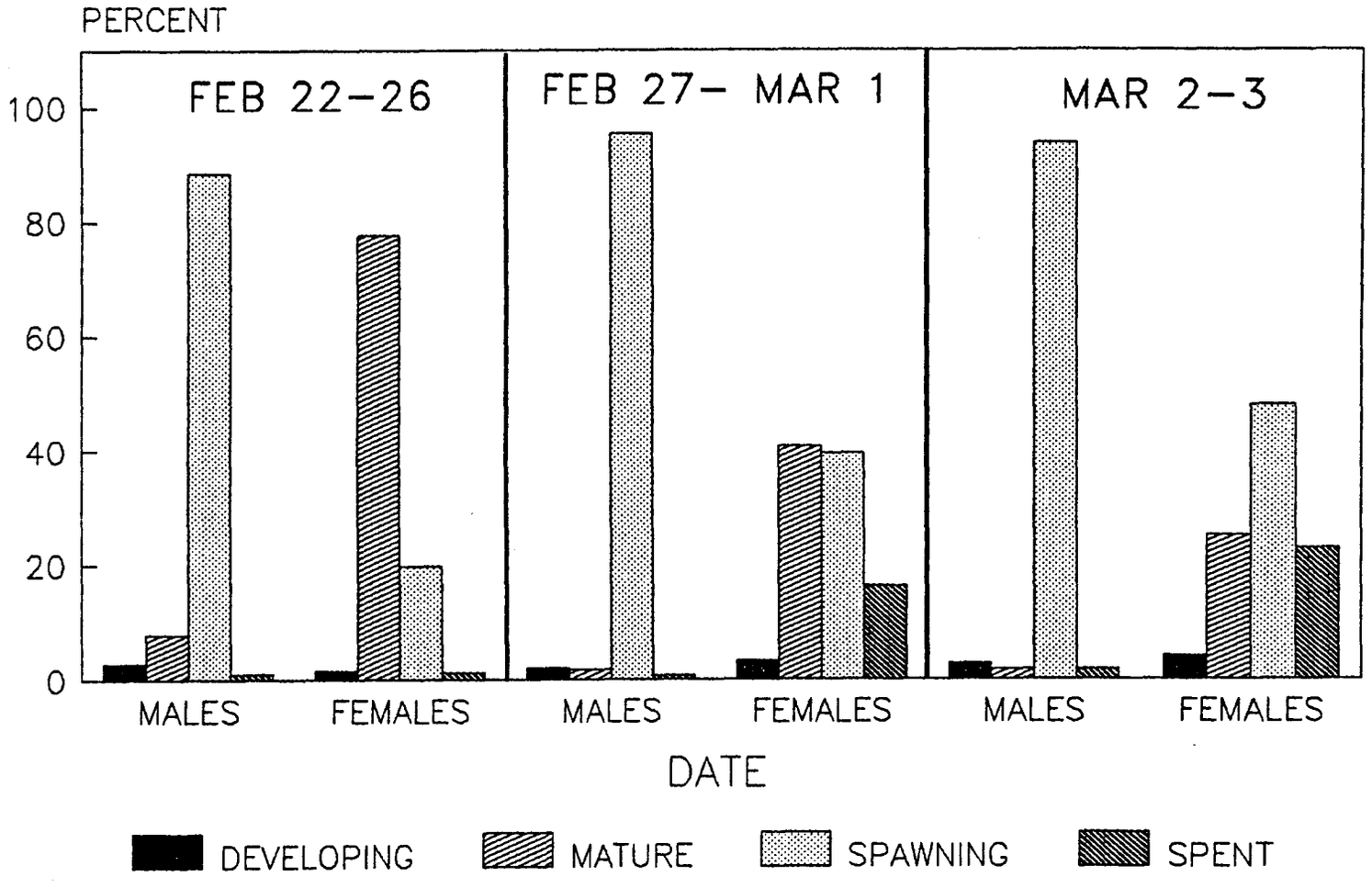

Fig. 5. Percent of male and female walleye pollock at four different maturity stages over time, in spawning aggregations near Bogoslof Island, Miller Freeman Cruise 88-1, Leg III.

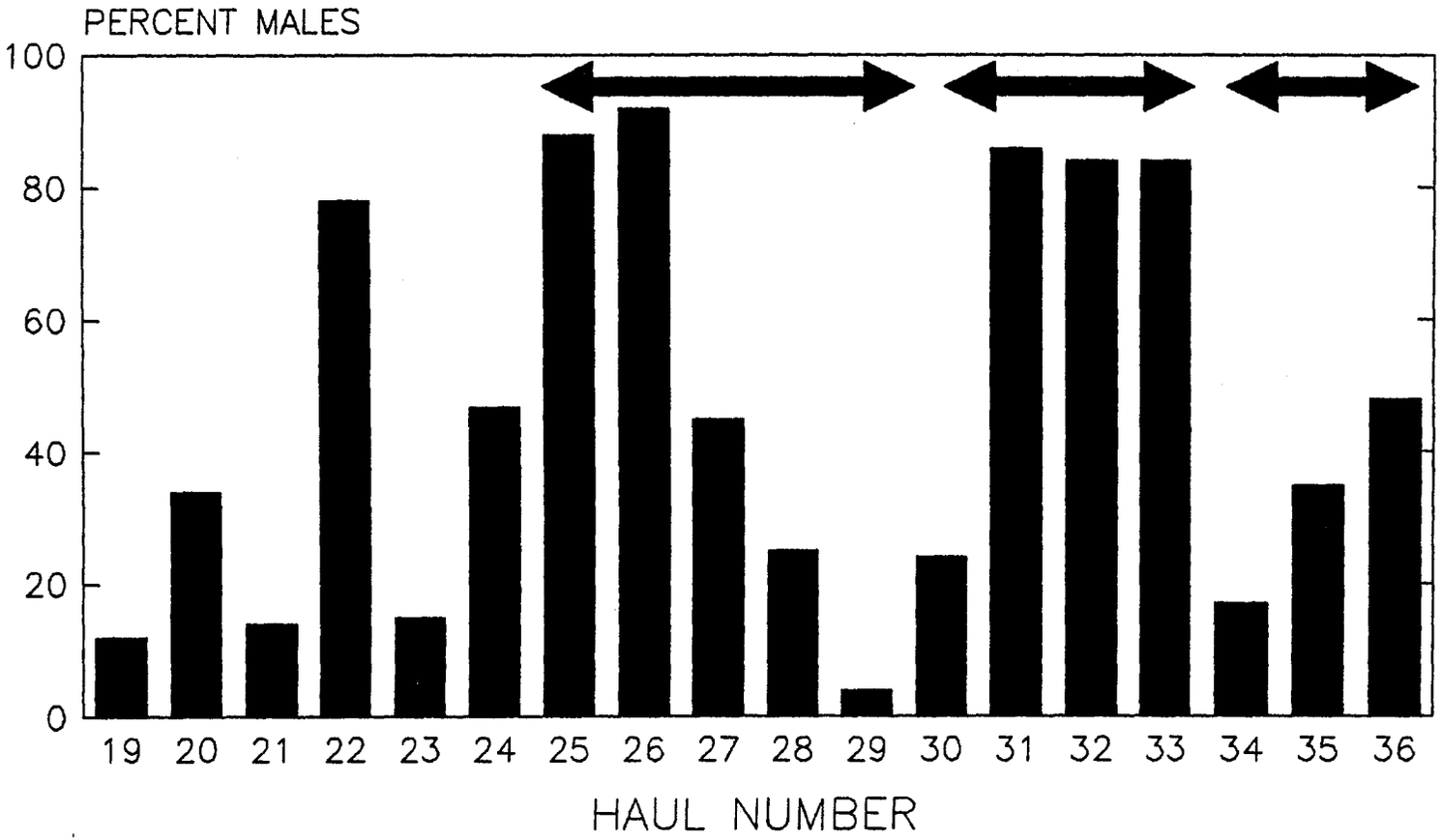

Fig. 6. Sex composition of walleye pollock observed in spawning aggregations near Bogoslof Island. Arrows indicate trawl hauls obtained from the same spawning aggregation (hauls 25-29, hauls 30-33, and hauls 34-36).